Technological Strategies and Exports: A study of Indian Basic Chemical Industry

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1. Introduction

The relationship between technological strategies and international competitiveness is a well-researched area in literature on industrial organization. Studies by Posner (1961), Vernon (1966), Krugman (1979), Fagerberg (1988), Kumar and Siddharthan (1994) and others clearly assert that differential technological capabilities are responsible for inter-industry as well as inter-firm variations in international competitiveness. This paper broadly follows the evolutionary theoretical approach proposed by Nelson and Winter (1982), Dosi (1988), Dosi, Soete and Pavitt (1992) and others, and its adaptation to developing countries' context by Siddharthan and Nollen (2004) and Narayanan (1998, 2006) to examine the relationship between technological strategies and export performance of firms belonging to the Indian Basic Chemical industry.

The Basic Chemical industry is one of the old and mature industries in India. However the industry is considered to be lagging behind the world standards due to the influence of India's protective policy regime till 1991. Thus the scope for competitiveness in the industry now lies principally in reducing the costs of production for the standardized products either through process innovations or through high scale operations. However, monopoly returns due to some specialized product development based on unexploited pioneering technology may not be totally ruled out. Liberalization process has also increased the possibility of intra-firm transfer of technology and management practices from advanced countries to the Indian Basic Chemical sector through foreign direct investments. As a result, the industry is undergoing rapid changes during the past one and half decade especially with respect to adoption of differential technological strategies (Bhat and Narayanan, 2006). It should be noted that though many empirical studies exist that have analyzed the effects of technological investments on competitiveness however only a few (for example Siddharthan and Nollen, 2004; Narayanan, 1998, 2004, 2006) have highlighted the fact that firm performance can also vary due to the presence of differential effects of technological investments in different combinations of technological investment modes chosen by the firm.

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Since there have been no serious studies in Indian Basic Chemical industry linking export performance to differential technological strategies adopted by firms, the present study attempts to fill this gap in the literature by searching answers to two questions. First, are there any systematic differences in the export performance of the firms due to adoption of different technological strategies? Here, the technological strategies of the firms are defined in terms of the simultaneous use of zero, one or more of the four basic technology investment modes- in-house research and development (R&D); market purchases of technology in two forms, namely, import of embodied technology by capital goods import and import of disembodied technology, that is, design, drawings, and formulae through lump sum, technical fees and royalties payments; and intra-firm transfer of technology through foreign equity participation. It should be noted that the option of not using any of the above four basic technological strategies is also considered to be a strategy, that is, passive strategy. The answer to the first question is hypothesized to be in affirmative and therefore the study would also try to address the next question, that is, which of the technological strategies is more effective in achieving better international performance? Answer to the second question would highlight the efficient technological strategies prevailing in the Indian Basic Chemical industry. In the process of investigation, those aspects of the industry would also get exposed where specific policy intervention may be required for further enhancing the international competitiveness of the firms in this industry.

The sample used in the present study consists of a balanced panel data of 91 firms over seven years (1997 to 2003) drawn from the Indian Basic Chemical industry. The data is analyzed using both cross-tabulations and Maximum Likelihood Estimation technique of the Tobit model. The sample consists of firms ranging from non-exporters to nearly 100 percent exporters, and hence the use of a Tobit model.

The following section would give an overview of the literature relating to determinants of export competitiveness. The theoretical and empirical evidences highlighting the relationship between technology and international competitiveness would be especially discussed. The third section would deal with the characteristics of the Indian Basic Chemical industry. The recent trends in the industry with respect to exports would also be highlighted. The fourth section would discuss the sample and variables being used in the study. Using the cross tabulations some important patterns in the relationship between variables would be highlighted. The fifth section would deal with the econometric model and hypotheses. The results of the econometric exercise would be presented in the sixth section. The final section would deal with the summary and discussions of the findings.

2. Literature Review

This section would give an overview of studies dealing with determinants of export competitiveness. The following subsection would deal with the evidences that highlight the relationship between technology and export competitiveness. Subsection 2.2 would highlight other determinants of export competitiveness such as size of firm, age of the firm, profit margin, vertical integration, and capital productivity. Empirical evidences from both developed and developing countries have been considered, however the focus is on export competitiveness in developing countries like India.

2.1 Technology and Export Competitiveness

In the early nineteen sixties Posner (1961) suggested that countries with similar production factor endowments may also trade with each other due to differences in the available technical knowledge in the countries. Further, the firm that introduced new product or process and enjoyed export monopoly may maintain the comparative advantage over its imitators by improving the original product or process innovation through continuous investments on R&D efforts.

On similar lines, Vernon (1966) put forth his product cycle approach for explaining trade between developed and developing countries. According to him the developed countries by virtue of their persistent investments in new technologies would have comparative advantage over developing countries in new and upcoming products. Thus, in the initial stages of the product development, exports would be from developed to developing countries. However, as the product becomes standardized, the direction of trade reverses. Krugman (1979) too argued that by virtue of their ability to exploit new technology the developed countries have an edge over the developing countries in exports of technology-intensive goods. However, in order sustain the advantage the firms in the technology-intensive industry of the developed countries would have to continuously innovate.

In the context of organization for economic cooperation and development (OECD) countries, Pavitt and Soete (1980) suggested that a relatively high expenditure of resources on innovative activities in an OECD country led to production of more competitive products and processes in that country that ultimately reflected in an increase in the world market export share for the country. Later, Fagerberg (1987) tested the technology gap approach to development and growth for industrialized countries and confirmed that level of technological development was highly important in determining differences in growth between the countries. In the following year, Fagerberg (1988) for a dataset obtained for OECD countries developed a model of international competitiveness that incorporated three sets of factors that dealt with the ability of the country to compete in technology, price, and delivery or capacity respectively. His results showed that technology and capacity factors were more important than price factor in explaining the medium and long run differences in international competitiveness across countries.

For Newly Industrializing Economies (NIEs), Lall (2000) considered data on manufactured exports as one of the important measures of technological performance. However, according to him this indicator could not distinguish between different levels of technology used in various product groups when data was considered at the country level.

To overcome such deficiencies of the macroeconomic empirical studies the advocates of evolutionary theoretical approach (Nelson and Winter, 1982; Dosi, 1984, 1988; Pavitt, 1984; Dosi, Soete and Pavitt, 1992) recommend making firm as the center of analysis. According to them inter firm asymmetries in innovative activities result in differences in competitiveness of the firms that ultimately determines the direction of international trade.

Empirical studies in both developed and developing countries have found varying evidences on the relationship between technological efforts and export competitiveness of firms. The

following subsections give an overview of some of the technology variables used in various empirical studies that would also be analyzed in the present study.

2.1.1 Research and Development

Most of the empirical studies on technology and competitiveness have considered technological efforts in the form of R&D investments. The studies that have found a positive relationship between R&D and export competitiveness include Aggarwal (2001) for medium-high technology industry in India (that includes sample of firms belonging to Other Engineering and Chemical industry), Basile (2001) for Italian manufacturing industry, and Ozcelik and Taymaz (2004) for Turkish manufacturing industry.

Others have found varying effects of R&D intensity on export competitiveness in the presence of additional specific classification of sample. For example Wakelin (1998) for a sample of UK manufacturing firms found that sector R&D expenditure had a positive effect on the probability of non-innovative firms being exporters but the same variable had a negative effect on the export propensity for innovative as well as non-innovative firms. Similarly, Zhao and Zou (2002) for Chinese manufacturing industry found that those firms that undertook R&D activity were more likely to export than others who did not do any R&D, however the export intensity of the exporters was negatively affected by R&D activities. Kumar and Siddharthan (1994) studied the determinants of export intensity for thirteen Indian industrial sectors covering low, medium and high technology industries individually. In line with the product life cycle theory, they found that R&D intensity was important in determining the export competitiveness for some of the low and medium technology industries (for Basic Chemical and dyestuff industry the coefficient of R&D intensity was insignificant) but not for any of the high technology industries. In contrast Bhaduri and Ray (2004), even in case of Indian high technology industries of Pharmaceutical and Electronics/Electrical found that the combined effect of firm size and R&D stock was very important in determining export performance, that is, large firms having large stock of R&D in both the sectors exported more.

Still other studies have found that technological efforts in terms of R&D have no effect on export competitiveness. Willmore (1992) for a large sample of Brazilian manufacturing firms found that the dummy variable differentiating firms with R&D program and those without turned out to be insignificant as a determinant of exports. In a recent study, Narayanan (2006) found coefficient of R&D intensity to be insignificant for the licensing period and the liberalization period in case of Indian Automobile industry. It is interesting to note that in the same paper Narayanan (2006) has found a negative relationship between R&D and the export performance of the firm for the deregulation period.

2.1.2 Foreign Equity Participation

Intra-firm transfer of tacit technology through foreign equity participation is another variable whose effect on export competitiveness has been examined in various studies. Most of these studies have found foreign equity participation to have a favorable influence on export competitiveness (Kumar and Siddharthan (1994) in five Indian industrial sectors; Aggarwal (2001) for Indian medium-high technology industries; Wignaraja (2002) for Mauritian Garment industry; Ozcelik and Taymaz (2004) for Turkish manufacturing industry; Bhaduri

and Ray (2004) for Indian Pharmaceuticals industry; Siddharthan and Nollen (2004) for Indian Information Technology industry; and Narayanan (2006) for Indian Automobile industry during the licensing and liberalization periods).

Athukorala et al. (1995) introduced separate foreign equity variables for affiliates of third-world MNCs and the developed country MNCs for Sri Lankan manufacturing industry. They found that while being a third-world MNC affiliate positively affected the probability to export for a firm, however being a developed country MNC affiliate had no effect. In case of Fabricated Metal Products industry in India Kumar and Siddharthan (1994) even found a negative effect of foreign equity participation on export performance.

2.1.3 Import of Disembodied Technology

Another non-R&D variable that has been considered in quite a few studies on exports is the expenditure on acquiring disembodied technology, that is, designs and drawings through lump sum, licenses, technical fees, and royalty payments. The findings for this variable have been mixed.

While Kumar and Siddharthan (1994) in case of Indian high technology industry, Sterlacchini (1999) in case of non-R&D performing small firms of Italian supplier dominated industries, and Siddharthan and Nollen (2004) in case of MNE affiliates of Indian Information Technology industry have found the effect to be positive, however in some other cases (Siddharthan and Nollen (2004) in case of licensees of Indian Information Technology industry and Narayanan (2006) in case of Indian Automobile industry during deregulation period) the effect is found to be negative. Some other studies like Ozcelik and Taymaz (2004) for Turkish manufacturing industry have found import of disembodied technology to be having no effect on export competitiveness.

2.1.4 Import of Embodied Technology

Another mode through which technology may be acquired is through imports of capital goods. Machines and equipments that have been designed and manufactured based on modern technology have the technological information embedded in them. Thus, these embodied technology imports may help a firm in producing higher quality products that are acceptable at world standards.

Sterlacchini (1999) for non-R&D performing small firms in Italy and Basile (2001) again for manufacturing firms in Italy have reported positive effects of import of capital goods on exports. However, in case of India, the studies have found the effect to be either negative (Siddharthan and Nollen (2004) for MNE affiliates in Indian Information Technology industry and Narayanan (2006) for Indian Automobile industry during deregulation period) or insignificant (Siddharthan and Nollen (2004) for licencees and domestic firms in Indian Information Technology industry and Narayanan (2006) for Indian Automobile industry during licensing and liberalization periods).

2.1.5 Interaction Between Technology Variables

As already noted in Section 1 very few studies have considered the differences in performance occurring due to the differential effects of technological investments in the firms that adopt different combination of technological strategies.

Siddharthan and Nollen (2004) in case of Indian Information Technology industry differentiated between MNE affiliates, licensees and the domestic firms. Therefore they introduced interactive technology variables in the econometric model for the complete sample. They found that foreign direct investments and import of technology through licenses and royalty payments together did not have a favorable effect on exports.

Similarly, Narayanan (2006) for the Indian automobile industry introduced interactive technology terms in his econometric analysis and found that only one interactive term, that is, in-house R&D investments with import of capital goods turned out to be statistically significant with positive sign but only during the deregulation period.

2.2 Other Determinants of Export Competitiveness

This subsection would look at some of the other non-technology related variables that have been considered important as a determinant of export competitiveness by various studies.

2.2.1 Firm Size

One of the most commonly used non-technology variables in the analysis of export competitiveness is size of the firm. The inclusion of firm size as a potential determinant of export performance in various studies has been due to the hypothesis that large firms with their vast resources and influential position have an edge over smaller firms in catering to the needs of domestic as well as international markets. Bonaccorsi (1992) carried out a survey of research studies that dealt with the relationship between firm size and export behavior with focus on Italian manufacturing industry. He found that though on the whole the findings of the literature on the relationship were mixed but majority of the studies emphasized a positive relationship. Other recent empirical studies that have found a positive relationship between firm size and export competitiveness include Basile (2001) who studied Italian manufacturing firms, Aggarwal (2001) for Indian medium and low technology industries, Zhao and Zou (2002) for Chinese manufacturing firms and Narayanan (2006) for the Indian Automobile industry.

Athukorala et al. (1995) for Sri Lankan manufacturing industry found that firm size positively affected the probability of a firm being exporter but had no effect on export intensity of the firm. In a recent study, Siddharthan and Nollen (2004) found a mixed effect of size variable on export performance of firms in the Indian Information Technology sector- for domestic firms taken alone size had a positive effect, for the MNE affiliates taken alone it had a negative effect and for licensees of technology taken alone it had no effect. At the same time for the sample as a whole, they found that in comparison to domestic firms, size factor in case of both MNE affiliates and licensees was disadvantageous for exports. Wignaraja (2002) for a sample drawn from the Mauritian Garment industry found that size of the firm did not matter for export performance.

Some others studies have found non-linear relationships between firm size and export competitiveness. Sterlacchini (1999) in case of Italian manufacturing industry found size to have an inverted 'U' relationship with export performance. Similarly, Kumar and Siddharthan (1994) found that the medium sized firms in seven out of thirteen Indian industries were more export competitive than either the smallest or the largest firms. However for another five industries (including Basic Industrial Chemicals) the size variable failed to be statistically significant. For Other Chemical Products industry Kumar and Siddharthan (1994) found that a minimum threshold size was required for the firms to become export competitive. Patibandla (1995) too for a sample drawn from Indian Engineering industry found the relationship between size and export performance to be 'U' shaped.

2.2.2 Firm Age

Another factor considered in empirical studies is the age of the firm. Age of the firm may affect the cost of capital and the firm's learning experience. In developing countries such as India, after liberalization, newer firms may find the domestic markets to be already crammed with older firms' products and therefore may try to seek the foreign markets right from the outset (Bhaduri and Ray, 2004).

Some empirical evidences are in favor of older firms performing better in exports sector (Roberts and Tybout (1997) in case of Colombian manufacturing plants). Others find that the younger firms with latest equipments and technology have an edge over older firms in export market (Bhaduri and Ray (2004), in case of Indian Electronics/Electrical industry). Still others find that age of the firm may not matter. Examples include Wignaraja (2002) for a sample drawn from the Mauritian Garment industry and Bhaduri and Ray (2004), in case of Indian Pharmaceutical industry.

2.2.3 Vertical Integration

Vertical integration has been considered important in determining the cost of production of a product. So, vertically integrated firms might be able produce products at lower costs by internalizing the various stages of production process and thus be able to capture the foreign markets by flooding it with cheap products. However, it should be noted that with the environmental regulations becoming stringent and with the opening up of the economy of developing countries like India, it might be more effective to subcontract the production of the raw materials to local or foreign specialized firms, especially in case of Chemicals and related industries.

The empirical evidences are mixed on the effect of vertical integration on exports. Narayanan (2006) for the Indian Automobile industry found vertical integration to be positively affecting export performance during the licensing period. However, for the other two periods, namely, deregulation and liberalization, he found vertical integration had no statistically significant effect. Willmore (1992) for a large sample of Brazilian manufacturing firms found higher vertical integration to worsen export performance.

However, Patibandla (1995) for a study on Indian Engineering established that being a subcontractor to another firm positively influenced the export performance of the

subcontractor firm. One can argue that when a subcontractor firm is able to perform better in international market it also implies that a vertically integrated firm (in the sense that the subcontractor firm is producing and so adding all the value to the product that it is exporting) is showing better export performance than the not so vertically integrated one.

Sterlacchini (1999) for Italian manufacturing industry established that being a subcontractor for another firm has a negative effect on the export performance of the subcontractor firm. In other words, higher vertical integration dissuaded international competitiveness. Similarly, Ozcelik and Taymaz (2004) found that share of input subcontracted to suppliers positively affected and share of output subcontracted by customers negatively affected export intensity for Turkish manufacturing industry. Thus, the firms that chose to subcontract the input to other firms rather than produce the complete product itself were able to have better export performance.

2.2.4 Profit Margin

Profit margin can also be included as a determinant of export performance since export activity is investment intensive and so would require funds from all kinds of sources. Further profits also reflect the tax benefit incentives given to the exporting firms. However, for the Indian Basic Industrial Chemicals industry Kumar and Siddharthan (1994) found profitability to be having a negative effect on export performance and therefore noted that the corporate tax concessions provided by the Indian government for the exporting firms was not having its desired effect.

3. Characteristics of Indian Basic Chemical Industry

Chemical industry is one of the oldest industries in the world as well as in India. Basic Chemical industry can be considered as a subset of the vast Chemical industry. The firms in Basic Chemical industry produce intermediate products such as industrial gases, organic and inorganic acids and bases, catalysts, dyes and pigments intermediaries, salts, metal compounds, and other minerals that are needed as inputs in various other industries including Leathers, Textiles, Dyes and Pigments, Paper, Plastics, Rubber, Pharmaceuticals, Food processing, and Chemicals itself.

Basic Chemical Industry can be characterized to be a high volume, low value added, limited product differentiated industry with high entry barriers due to high capital requirement and stringent regulations (KPMG-CHEMTECH, 2003). Therefore competitiveness can be mainly in the form of bringing in efficiency in the underlying process of production. However, sometimes development of a new product can give a definite monopoly power to the Basic Chemical producer.

Indian Chemical industry was highly protected during the inward looking regime with high tariff rates and quotas discouraging competition from abroad. Also, restriction on production, with the help of licensing, ensured that there was no competition even from domestic firms. The growth of Indian Chemical industry during that period was mainly based on the requirements and opportunities provided by the import substitution policy regime. As part of the import substitution policy, Indian government gave tax reduction and other incentives to encourage firms to invest in in-house R&D for product and processes innovations. However,

the amount spent by Indian firms on R&D was, and still is, hardly anything compared to the world players (Ganguly 1999; KPMG-CHEMTECH, 2003). Many small and medium scale chemical enterprises flourished during the protected and licensing regime in the Indian Chemical industry. The few larger and older firms that could have become their competitors did not invest in any meaningful R&D or marketing or human resource development. A few multinationals that existed during that time fared better than the domestic firms in performance due to access to R&D and technological options from the parent firms in other countries. However, majority of the firms in the Indian Chemical industry are presently low margin but high volume producers and traders (Ganguly, 1999).

The global scenario has changed a lot in the last half a century; however the Indian firms where left untouched by these changes during the inward looking policy regime. With liberalization, most of the restrictions have been removed and the Indian Chemical industry is now thrown open to the global challenges. Most chemicals and petrochemical products have now become freely importable and tradable, automatic approval of foreign equity up to 51 percent in most drugs and formulations is now possible, and with India becoming a signatory to the general agreement on tariffs and trade (GATT) in 1993, firms in India have to adhere to both product and process patents (Trivedi et al., 2000). Thus the competitiveness for Indian Chemical firms now lies in meeting with the global challenges that include discovering new environment and ecology friendly technologies, reducing the exploitation of hydrocarbon or petroleum based energy source, focusing on speciality chemical production rather than on cyclic commodity chemicals (Ganguly, 1999). Therefore in the last one and a half decades one can witness a lot of activities taking place in the Indian Chemical industry. [‡]

The threat that the firms are facing can easily be seen by looking at the number of requests of anti-dumping petition filed by Indian chemical manufacturers. Anti dumping petitions includes one on import of pentaerythritol (that is used in production of alkyl resins, synthetic rubber, printing inks, plastics, explosives, pharmaceuticals, and synthetic lubricants) from Canada, Japan and Taiwan filed by Kanoria Chemicals & Industries Ltd. Another one is on imports of phenol (that is used in manufacturing of plywood, laminates, and particle boards) from the European Union, Singapore and South Africa filed by Hindustan Organic Chemicals Ltd (HOCL). Alkali Manufacturers' Association of India (AMAI) has filed an anti-dumping petition against dumping of caustic soda from China and South Korea. However, later, Indian Agro and Recycled Paper Mills Association (IAPMA) asked for the removal of anti-dumping duty on caustic flakes and caustic lime citing the abnormal increase in prices of these products after the imposition of anti-dumping duty to be a cause of concern.

The firms in the industry are trying to compete through mergers and acquisitions, collaborations, and rigorous in-house R&D. Most of the collaborations in the industry during the last two decades have taken place with firms in European Union (mainly in Germany and United Kingdom), North America (mainly United States), and North East Asia (mainly Japan) countries. For example, EPIC Enzymes Pharma & Industrial Chemicals Ltd that

[‡] The source of information on anti-dumping cases, collaborations, and mergers and acquisitions is various articles in the Internet version of Business Line provided by THE HINDU group of publications. Capitaline2000 database too provides some information on collaborating countries, collaborator firms, and type of collaboration.

manufactures agricultural and industrial chemicals entered into a technical and financial collaboration with Feinchemi Schwebda of Germany in 1993. EPIC has thus set up a plant at Patalganga to produce 500 tpa of diethyl thiophosphoryl chloride, an intermediate for manufacturing insecticides. Cabot Corporation, USA has majority shareholding in Cabot India Limited (CIL) that has been manufacturing furnace-type carbon black. In 1990, CIL entered into a technology-transfer agreement with Cabot for its latest high-temperature reactor technology. Ciba Specialties India merged its operations with Indo Swiss Textile Chemicals and Pigment Specialties India. Similarly, Nalco Chemicals, a major water treatment chemicals supplier acquired Aqua Chemicals and Aquazur India to enhance its ingredients and services business. Nalco Chemicals has also tied-up with Degremont India, Tractabel of Belgium, and Lyonnaise of France for its water-treatment equipment business. Clariant India Ltd in which has equity participation from Clariant International Ltd of Switzerland has introduced new products such as dyestuffs with very low salt content and environmental-friendly syntans. Albright & Wilson through its innovative efforts has developed a new catalytic system based on Heck Chemistry that supports the first commercial scale naproxen plant (Ganguly, 1999).

When it comes to capturing markets in the chemical sector, China is recognized as a tough competitor for India. The per capita consumption of chemicals in both India and China is small compared to the industrialized countries (Malvi, 2003). However, it should be noted that China with its vast natural resources, cheap and efficient labor, technological penetration, and export-oriented industries is in a better position to capture markets as compared to India (Malvi, 2003). Still the Indian chemical sector including the Basic Chemical sector has witnessed some growth in exports during the past few years. Tables 1a and 1b depict the export trend in the Basic Chemical industry. The firms in the Basic Chemical industry as well as in the present sample can be grouped (based on the end products produced by the firms) under the categories defined by the Indian Trade Classification based on Harmonised System or the ITC (HS) code. The ITC (HS) code categories for the present sample at two-digit level include HS 28 (inorganic chemicals; organic or inorganic compounds of precious metals, of rare-earth metals, or radioactive elements, or of isotopes), HS 29 (organic chemicals), HS 36 (explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations), and HS 38 (miscellaneous chemical products).

Table 1a: Export growth of Basic Chemicals during 1997-98 to 2003-04 period

	Sl. No.	ITC HS Code → Financial Year ↓	HS 28	HS 29	HS 36	HS 38
Annual Export Rate of Change (in Percentage)[1]	1	1997-98	-11.32	22.34	-13.93	34.19
	2	1998-99	-23.90	-6.03	-46.94	-15.34
	3	1999-00	0.85	19.91	24.33	20.24
	4	2000-01	47.74	26.36	31.22	15.10
	5	2001-02	12.06	-6.98	-9.20	-3.17

	6	2002-03	52.34	30.86	18.31	10.84
	7	2003-04	5.46	34.10	10.52	20.12
Value of Exports (In US $Million) in 1997-98			207.75	1214.98	15.17	350.65
Value of Exports (In US $Million) in 2003-04			424.09	2823.55	15.59	575.27
Compound Growth Rate of Exports for the period 1997-98 to 2003-04 (in Percentage)[2]			12.63	15.09	0.456	8.60

[1] Data source is the data available on the website of Ministry of Commerce and Trade

[2] Calculated by author using the value of exports (in US $ Million) for the periods 1997-98 and 2003-04 from the data source[1]. Here export growth rate is calculated as: 100*(Antilog [1/6*Log (Value in period 03-04/Value in period 97-98)] – 1).

Table 1a gives the trend in exports for the four categories during the period from 1997-98 to 2003-04. The source for the data is the database available on the website of Ministry of Commerce and Trade, Government of India. As can be observed in the Table 1a, the maximum export growth rate is for HS 29 group which consists of organic chemical producers, followed by HS 28 and HS 38 which consist of mixture of organic (petrochemical and coal based) and inorganic chemicals. The lowest export growth rate was registered for HS 36 that consists of firms producing explosives. This is logical since there is still licensing and other restriction on the production of explosives. It should be noted that during 1998-99 all the four groups registered a negative export growth rate. This is more likely to be an aftermath of the nuclear tests conducted by India at Pokharan in May, 1998.

Table 1b: Top three regions in descending order of value of exports (in US$ Million within the brackets) for HS 28, HS 29, HS 36, and HS 38 chemicals during the financial years[1]

Financial Year	HS 28	HS 29	HS 36	HS 38
1997-98	N. America (41.67) NE Asia (39.4) ASEAN (33.11)	EU (385.15) NE Asia (263.56) N. America (161.84)	ASEAN (3.87) WANA (3.73) EU (2.63)	EU (132.57) WANA (69.4) NE Asia (35.45)
1998-99	NE Asia (28.71) EU (24.23) WANA (18.76)	EU (338.37) NE Asia (232.48) N. America (166.53)	WANA (2.06) W. Africa (1.4) ASEAN (1.1)	EU (96.95) WANA (65.44) NE Asia (36.08)
1999-00	WANA (28.24) EU (25.06) NE Asia (23.3)	EU (377.96) NE Asia (278.89) N. America (185.05)	EU (1.89) ASEAN (1.56) E. Africa (1.48)	EU (110.4) WANA (100.86) ASEAN (51.43)
2000-01	EU (38.17) S. Asia (30.81) ASEAN (30.19)	EU (445.89) NE Asia (357.03) N. America (257.39)	ASEAN (3.28) WANA (2.83) E. Africa (1.62)	EU (121.08) WANA (106.93) ASEAN (64.24)
2001-02	WANA (82.66) NE Asia (42.37) EU (30.35)	EU (426.94) NE Asia (303.68) N. America (261.86)	WANA (2.8) ASEAN (1.86) E. Africa (1.71)	EU (132.94) ASEAN (67.47) WANA (48.7)
2002-	NE Asia (104.83)	EU (568.01)	WANA (3.66)	EU (134.9)

03	WANA (92.35) Other CIS (48.73)	NE Asia (404.69) N. America (303.33)	E. Africa (2.44) W. Africa (1.57)	ASEAN (80.2) WANA (60.96)
2003-04	NE Asia (127.01) WANA (59.24) ASEAN (49.28)	EU (718.47) NE Asia (498.51) N. America (404.71)	E. Africa (3.34) WANA (3.12) W. Africa (2.33)	EU (168.6) ASEAN (91.57) WANA (67.93)

[1] Data source is the data available on the website of Ministry of Commerce and Trade

Table 1b depicts the top three regions to which the products in the four ITC (HS) categories were exported during 1997-98 to 2003-04. As can be observed from Table 1b, in each year the value of organic chemical (HS 29) exports leads the values in other categories. Organic chemicals are exported mainly to European Union (EU), North East Asia (NE Asia), and North America (N. America). It should be noted that majority of foreign collaborators of Indian Basic Chemical firms too come from these regions. Again, European Union is the most popular region for the exports of the miscellaneous chemicals (HS 38, that consists of mainly speciality organic or inorganic chemicals that have not been incorporated in other HS categories). North East Asia, Association of Southeast Asian Nations (ASEAN), and West Asia North Africa (WANA) regions are also importers of Indian miscellaneous chemical exports. The top three destination regions for exports of HS 28 products (consisting of both organic and inorganic chemical compounds) have been varying. However, North East Asia and WANA feature in the top three export destinations for HS 28 products in most of the years. HS 36, which consists of explosives, is the least contributor to the exports among the four categories and seems to be mainly catering to the needs of the oil-rich WANA countries and the African subcontinent.

4. The Sample, Variables, and Cross Tabulations

The following subsection gives an overview of the sample and variables used in the study. Subsection 4.2 tries to investigate the emerging relationship pattern between the explanatory variables, especially technology variables, and export intensity through cross tabulations.

4.1 Sample and Variables

As mentioned earlier, the balanced panel data consists of 91 firms for seven years, from 1997 to 2003, drawn from the Indian Basic Chemical industry. The source for the data is the Capitaline2000 database provided by Capital Market. Capital Market follows its own classification and as per its classification the firms considered in the study belong to the 'Chemicals' industry. However, as discussed earlier, on analyzing the major end products produced by the firms in the sample, the firms were found to be producers of basic chemicals. Hence the sample in the present study is said to belong to Indian Basic Chemical Industry.

The sample consists of observations on firms that export as well those that do not export. Some of the firms export in all the seven years, others export in some of the years but not in all, and still others export in none of the years considered in the study. Further, the kind of technological investment strategy used by these firms also varies during the period- some firms invest in all the technological sources in all the years of the sample, others invest in some technological sources in some years, and still others use none of the technological strategies. Thus, the balanced panel tries to incorporate the diverse technological strategies that each of the firm in the sample might have experimented with during the seven years.

Table 2 shows the variables being used in the study and their definitions. All the variables, except age of the firm and the dummy variables, have been deflated. The explained variable is export intensity (EXPI) that represents the share of free on board (FOB) exports in total sales turnover for the firm. Four types of technology variables- in-house R&D intensity (RDI), import of embodied technology intensity (MKI), import of disembodied technology imports (LRI), and foreign equity participation (D_{fe}) have been considered as potential determinants of export intensity.

Table 2: The Variables and their Definitions

Sl. No.	Variable	Symbol	Definition Used in the Study
1	Export Intensity	EXPI	(FOB Value of Exports / Sales Turnover of the firm) * 100
2	R&D Intensity	RDI	(Expenditure on R&D / Sales Turnover of the firm) * 100
3	Import of embodied technology (capital goods) Intensity	MKI	(Expenditure on import of capital goods / Sales Turnover of the firm) * 100
4	Import of disembodied technology Intensity	LRI	(Lump sum, royalty, and technical fees payments in foreign currency / Sales Turnover of the firm) * 100
5	Age of the firm	AGE	One added to the difference between the year of incorporation and the year in the study
6	Profit Margin	PROFIT	(Gross profit earned by the firm in the year / Sales Turnover of the firm) *100
7	Vertical Integration	VI	(Value Addition by the firm / Sales Turnover of the firm) * 100
8	Capital Productivity	CAP	(Sales Turnover of the firm / Gross Block of the firm) * 100
9	Market Share	MS	(Sales Turnover of the firm / Sum of the Sales Turnover of all the firms) * 100
10	Foreign Equity Participation	D_{fe}	D_{fe} = 1 when foreign equity participation exists D_{fe} = 0 otherwise
11	Organic Chemical Firm	D_{org}	D_{org} = 1 when observation is organic chemical producer D_{org} = 0 otherwise

Most of the empirical studies (see Section 2 for the details) have considered size variable in their export equations. In a scale intensive industry such as Basic Chemical industry, to analyze the effect of size factor on the export intensity of the firms, market share (MS) of the firm has been considered as an explanatory variable.

Venturing into foreign market is quite risky with high requirement of investments. However due to stagnation of the domestic markets and with the expectation of future gains in foreign markets firms might still be willing to take the risk. At the same time in order to reduce the risk and to get the best deal the firms are likely to invest on gathering information about the foreign market. Again, the firms will need to advertise themselves as the potential supplier. All such activities require finance but not all firms would be influential enough to fulfill all their needs using financial markets. Therefore the firms are likely to reinvest their profits for export related activities and that justifies inclusion of profit margin (PROFIT) of the firm as an explanatory variable.

Age of the firm (AGE), as discussed earlier reflects the experience of the firm, and its ability to exert power, whether to get loans or to reduce the cost of raw materials. Vertical integration (VI) of the firm determines which kind of production method is more important for export competitiveness- production of the complete product within the firm or production of only the final product by using the specialized raw materials provided by the subcontractors.

Another variable considered is capital productivity (CAP). Some explanation needs to be given for inclusion of this variable in the present study. It should be noted that many studies (Willmore, 1992; Kumar and Siddharthan, 1994; Athukorala et al., 1995; Zhao and Zou, 2002; Ozcelik and Taymaz, 2004; Siddharthan and Nollen, 2004; Narayanan, 2006) on exports have considered capital intensity (capital-output or capital-labor) ratios as potential determinants of export performance, however none (at least the authors have not come across any) that have considered capital productivity or output capital ratio.

If we consider Indian studies then in case of six low and medium technology industries, including industrial and other chemicals, Kumar and Siddharthan (1994) found a negative effect of capital intensity on export performance. The authors attributed this finding to the low wages prevailing in the economy during that time. At the same time for two of the three high technology industries considered in the study Kumar and Siddharthan (1994) found the relationship to be positive one. Similarly, for Indian Information Technology industry, a high technology industry, Siddharthan and Nollen (2004) find capital-output ratio to be having a positive effect on export performance of the licensees and domestic firms. For the liberalization period, Narayanan (2006) found the coefficient for capital intensity to be positively affecting export competitiveness in Indian Automobile industry.

It should be noted that the Basic Chemical industry is not as capital intensive as the Pharmaceutical industry. Moreover, if we look at the history of Indian Basic Chemical industry, during the inward looking regime the firms in the industry were operating below their capacity due to licensing restrictions. After liberalization and abolition of scale restrictions the immediate step that the firms took was to utilize the complete capacity and churn out products at full scale of operation. In such a scenario many of the firms might have got surplus of products over and above the domestic demand that they would have tried to sell in foreign markets. Therefore, in the present study capital productivity (or output-capital ratio that represents how efficiently the assets of the firms have been utilized for production

of output) is considered as a more relevant variable than capital intensity as a potential determinant of export performance of firms in Indian Basic Chemical industry.

Table 3: Minimum value, maximum value, mean, and standard deviation for the sample

Variables	Minimum	Maximum	Mean	Std. Deviation
EXPI	0	99.321	15.827	24.087
RDI	0	6.710	0.386	0.970
MKI	0	0.397	0.004	0.02
LRI	0	4.610	0.114	0.466
AGE	1	82	25.74	14.31
PROFIT	-211.111	66.437	4.375	23.115
VI	2.992	433.333	35.178	23.618
CAP	4.639	1310.000	178.872	180.150
MS	0.0009	7.963	0.892	1.107
D_{fe}	Number of Observations that have Foreign Equity participation = 219 (34.38%)			
D_{org}	Number of Observations that are Organic Chemical producers = 441 (69.23%)			

Total Number of Observations = 637

Many observations in the present sample are producers of organic chemicals (refer to Table 3). Therefore, to investigate whether product specific factors may bring in the differences in export performance of a firm, a dummy variable (D_{org}) has been included that differentiates the organic chemical producers from the inorganic chemical producers.

Table 3 shows the mean, standard deviation, maximum, and minimum values for the variables. For the dummy variables, the frequency of their occurrence (with percentage of the total in the brackets) in the dataset has been mentioned. As can be seen, the dataset contains non-exports to nearly hundred percent exporters; however, the mean of export intensity is only around sixteen percent. The maximum intensity of the technology variables- in-house R&D, import of embodied technology and import of disembodied technology is below seven percent. The mean intensity value is highest for R&D and lowest for import of capital goods. More than $1/3^{rd}$ of the observations have foreign equity participation. The observations in the sample are fairly experienced with the mean age of the firm being approximately 26 years. Profit margin ranges from highly loss making ones to moderately high profit making ones. The firms in the sample are on an average moderately vertically integrated. The mean capital productivity (output-capital ratio) is quite high, but it should also be noted that the standard deviation for the variable is also the highest. There does not seem to be any clear monopolist in the market since the maximum market share for an observation in the sample is around 8 percent and the mean is only around 1 percent. Nearly 70 percent of the observations in the sample are producers of organic chemicals.

4.2 Cross Tabulations

This subsection would try to investigate the possible pattern emerging regarding the relationship between the explanatory variables, especially the technological strategy variables, and export intensity. Tables 4 and 5 show the distribution of the technological strategies with export performance, Table 6 differentiates between organic and inorganic producers, and Table 7 presents the correlation matrix for the variables used in the study.

Table 4: Exporters, Non-Exporters, and Technological Strategy Distribution

Row No. ↓	Column No. →	1	2	3	4
	Exporter/Non-Exporter → / Technological Strategy ↓	Number of Non-Exporters	Number of Exporters	Total (Row)	Percentage of Exporters as a ratio of Total (Row)
1	Not using any Technological Strategy (Passive)	98	105	203	51.72%
2	Using some Technological Strategy (Active)	90	344	434	79.26%
	(2.1) Using a Single Strategy	44	127	171	74.27%
	(2.2) Using Multiple Strategies	46	217	263	82.51%
3	Total (Column)	188	449	637	70.49%

As can be observed from Table 4, in the sample though the number of technologically active and technologically passive non-exporters is nearly the same; however, when we look at the exporters, the technologically active ones outnumber (by more than three times) the passive ones. In other words, the percentage of technologically active exporters is higher than the percentage of passive exporters. This observation is in line with the hypothesis of various other empirical studies that technological investment can be an important factor in determining whether a firm is an exporter or not. Further, more than 60 percent (217 out of 334) of the technologically active exporters follow a combination strategy rather than a single strategy. Again, the number of non-exporters for both single and multiple technology users is nearly the same.

Table 5 shows the distribution of the average export intensity for the various technological strategies. As can be clearly seen the maximum as well as the average export intensity for the technologically active firms is higher than the passive ones. From Table 5 one can see that among the single technological strategies doing in-house R&D is most popular (68 observations) followed by foreign equity participation (48 observations). A comparison of row 2(a) with row 2(b) in Table 5 reveals that maximum import intensity, average export intensity, and average export intensity for only exporters is higher for single strategy users

than for multiple strategy users even though the multiple strategy users exceed single strategy users in sheer numbers.

Table 5: Average Export Intensity for various Technological Strategies (Total 637 Observations)

Sl. No.	Techno-logical Strategy	Sub-Strategy	NOB	Max. Export Inten. (%)	Avg. Export Inten. (%)	Avg. Export Inten. (%) for only Exporters
1	Technologically Inactive	**Observations that are technologically passive**	**203 (31.87%)**	**68.776**	**7.950**	**15.370**
2	Techno-logically Active	**Observations that are technologically active**	**434 (68.13%)**	**99.321**	**19.512**	**24.617**
		(a) Single Strategies	171 (26.84%)	99.321	21.846	29.515
		Only in-house R&D	68 (10.67%)	93.365	17.522	27.302
		Only Import of Embodied Technology	38 (5.96%)	93.069	25.713	28.737
		Only Import of Disembodied Technology	18 (2.83%)	92.839	22.969	25.840
		Only Foreign Equity Participation	48 (7.54%)	99.321	22.664	34.820
		(b) Combinations of more than one (Multiple Strategy)	263 (41.29%)	98.235	17.946	21.750
		R&D with others	**181 (28.41%)**	**93.750**	**14.192**	**17.011**
		R&D with Import of Embodied Technology	130	93.750	16.555	18.394
		R&D with Import of Disembodied Technology	105	79.127	8.481	11.132
		R&D with Foreign Equity Participation	109	83.840	11.186	13.547

The row following 2(b) in Table 5, that is 'R&D with others', shows that the combination of R&D with other technological strategies is quite popular with approximately 28 percent of the total observations (and nearly 70 percent of the multiple strategy users) opting for it. However, the average exports intensity for the combination of R&D and other technological strategies is lower than the average export intensity for all the multiple strategies taken together. This suggests that presently a strategy of combining R&D with other technological modes may not be that effective for competing in the export market for firms in this industry. But when we consider subdivisions within 'R&D with others' combination firms the strategy of combing in-house R&D with embodied technology imports has the highest average export

intensity. Again, one should note that of the four single technology strategies, firms importing capital goods have highest average export intensity. It therefore seems that import of capital goods, among the four technological strategies considered, has the most favorable effect on export competitiveness in Indian Basic Chemical industry.

As the discussion in the above two paragraphs suggests, there could be differences in the effects of technological investments according to the combination strategy used by the firm. In other words the effect of the same technological investment variable on export performance could be different when the firm uses single strategy and when the firm uses a combination strategy. For example in-house R&D when used alone might be of explorative type, which may result in better quality or even new product that in turn may give a monopoly power to the innovator in the export market- at least till the product is imitated or substituted. However when a firm that is importing technology also makes R&D investments, the R&D is most likely to be of adaptive type that could help the firm in enhancing its domestic market share by introducing a superior quality product by local standards but may not be effective in capturing foreign markets that might require still higher standards.

Table 6: Export Performance for Organic and Inorganic Firms

	Number of Observations	Average Export Intensity	Number of Exporters	Average Export Intensity for only Exporters
Organic Chemical	441	18.267	319 (72.34%)	25.254
In-Organic Chemical	196	10.337	130 (66.33%)	15.584
Total	637	15.827	449	22.454

Table 6 tries to highlight the differences in export performance for the Organic and In-organic Chemical firms. The random sample drawn from the population seems to be skewed towards organic chemical producers with nearly 70 percent of the observations consisting of such observations. From Table 6, one can observe that the percentage of organic chemical producers who are exporters is more than percentage of exporters who are inorganic chemical producers. Further, the average export intensity for organic chemical producers is closer to average for the whole sample and higher than that of inorganic chemical producers.

Table 7: Correlation Matrix ***(NOB = 637)***

Variables	EXPI	RDI	MKI	LRI	AGE	PROFIT	VI	CAP	MS
EXPI	1.00								
RDI	0.037	1.00							
MKI	0.063	-0.018	1.00						
LRI	-0.082	-0.042	0.043	1.00					
AGE	**-0.187**	**0.266**	-0.027	**0.187**	1.00				
PROFIT	0.087	0.093	0.092	0.098	0.005	1.00			
VI	-0.080	-0.025	0.004	-0.055	0.022	**-0.405**	1.00		
CAP	-0.019	0.096	-0.071	0.080	**0.144**	**0.122**	**-0.332**	1.00	
MS	-0.027	**0.523**	0.017	**0.155**	**0.293**	**0.092**	**-0.109**	**0.106**	1.00

Note: Bold values represent 1% significance and underlined ones represent 5% significance respectively

Correlation matrix between the variables is depicted in Table 7. As can be observed, of the technology variables- in-house R&D intensity, import of capital goods intensity, and import of disembodied technology intensity, only import of disembodied technology has a statistically significant correlation coefficient with export intensity, however with a negative sign. The other two technology variables though have positive correlation coefficient with export intensity, but are not statistically significant. Age and vertical integration too have statistically significant negative correlation coefficient with export intensity. In contrast, profit margin has a statistically significant positive correlation coefficient with export intensity. One can also observe correlation among the explanatory variables. For example the older firms are also the ones who have higher market shares and are investing more on in-house R&D. Similarly higher vertically integrated firms are also the ones who have smaller capital productivity and are earning lower profits. However, it should be noted that the correlation coefficient values are low and so there is less likelihood of multicollinearity problem in the econometric analysis.

5. The Econometric Model and Hypotheses

The sample data used for the present study consists of a large number of observations taking zero values for the explained variable- export intensity. Therefore, for such censored sample where information on regressand is available only for some observations, Tobit or censored regression model is the most appropriate technique (Green, 2002; Gujarati, 2003; Siddharthan and Nollen, 2004; Narayanan, 2006). The underlying methodology of estimation in Tobit model is the maximum likelihood estimation technique and not the least-square estimation technique. Statistically, a general Tobit model can be expressed as:

$$Y_i = \beta_0 + \beta_1 X_{1i} + ... + \beta_n X_{ni} + u_i,$$

$$Y_i^* = 0 \quad \text{if } Y_i \leq 0,$$

$$= Y_i \quad \text{if } Y_i > 0. \qquad \text{-----(1)}$$

where Y_i^* is the regressand and X_{1i} to X_{ni} are the n regressors.

The present study would also use the Tobit model with export intensity (EXPI) as the explained variable. The model is defined as:

$$EXPI = \alpha_0 + \alpha_1 RDI + \alpha_2 MKI + \alpha_3 LRI + \alpha_4 AGE + \alpha_5 PROFIT + \alpha_6 VI + \alpha_7 CAP + \alpha_8 MS + \alpha_9 MS^2 + \alpha_{10} D_{fe} + \alpha_{11} [RDI*MKI] + \alpha_{12} [RDI*LRI] + \alpha_{13} [RDI*D_{fe}] + \alpha_{14} D_{org} + u_1$$

$$EXPI^* = 0 \quad \text{if } EXPI \leq 0$$

$$= EXPI \text{ (as above)} \quad \text{if } EXPI > 0 \qquad \text{-----(2)}$$

The symbols stand for the corresponding variables as defined in Subsection 4.1. It should be noted that Hausman test was carried out on a subset, consisting of only exporters, derived from the original balanced panel dataset in order to determine which of fixed and random effects model would be more suitable for the analysis. Since the test rejected fixed effects model with Chi^2 value of 19.39 (and probability > Chi^2 = 0.1114), therefore a fixed effect econometric model was not used for the present study.

In the present model, the four technology variables (RDI, MKI, LRI, and D_{fe}) have been included to examine the differences in the effects of the four technology investment modes on export performance. In the context of Indian Basic Chemical industries the empirical

evidences on effect of R&D on exports are mixed (Kumar and Siddharthan, 1994 for Basic Industrial Chemicals and Dyestuff industry found the coefficient to be insignificant and Aggarwal, 2001 for medium-high technology including Other Engineering and Chemical industry found coefficient to be positive). Again, the correlation coefficient of R&D intensity with export intensity in Subsection 4.2 is found to be positive, but insignificant. At the same time, the analysis of the present sample in Subsection 4.2 reveals that doing in-house R&D may not be a suitable technological strategy for enhancing export competitiveness. Therefore one cannot definitely comment on the possible sign of the R&D intensity variable.

Basile (2001) in case of Italian manufacturing firms had found investment on capital equipments aimed at developing new products and employing less labor to be having a favorable effect on export performance. For the present sample taken from Indian Basic Chemical industry too import of capital goods seems to be having a favorable influence on export intensity in cases where firms are using a technological strategy that includes import of capital goods as an intrinsic part (see discussion in Subsection 4.2). Therefore, a positive sign is expected for the coefficient of MKI.

When it comes to import of disembodied technology, that is, import of designs and drawings against licensing, royalties, and technical fees payments (LRI) the empirical evidences dealing with various industries in different countries are mixed. In the Indian Industrial Chemicals context, Kumar and Siddharthan (1994) found the coefficient of this variable to be insignificant. However since the coefficient of correlation between LRI and EXPI in Subsection 4.2 was found to be statistically significant with negative sign for the present sample therefore it is hypothesized that the coefficient of import of designs are drawings may take a negative sign.

Studies on India such as Aggarwal (2001) for medium-high technology firms have found foreign equity to positively determine export performance of the firms. Kumar and Siddharthan (1994) though found foreign equity stake to positively affect exports in five Indian industries, but Chemical industry was not one of them. However, most of the empirical studies are in favor of foreign equity participation being important for developing country firms' export performance especially since the developing country firms can use the brand names and managerial skills of foreign firms to make a niche in foreign markets. Further, in the present sample too many firms are showing affinity towards having foreign equity participation. Therefore it is hypothesized that D_{fe} will be positively affecting export intensity.

Studies like Siddharthan and Nollen (2004) and Narayanan (2006) have introduced interactive technology variables to analyze the differential effects of technological investments on export competitiveness for the firms that use specific technological combinations. From the discussions on Tables 4 and 5 in Subsection 4.2 it is clear that in the present sample taken from Indian Basic Chemical industry many firms are multiple technological strategy users with nearly 70 percent of them using R&D as an integral part of the combination technological strategy. Therefore in the present study too, to explore the existence of any joint effect of technology variables, especially in case of firms that use a combination of R&D with others, three more interactive variables, namely, R&D with import

of embodied technology [RDI*MKI], R&D with import of designs, drawings, and formulae [RDI*LRI], and R&D with foreign equity participation [RDI*D_{fe}] have been included. It is difficult to predict the direction of effect of these three interactive variables on export performance in the present study. However, based on the discussion in Subsection 4.2, the interactive term [RDI*MKI] is likely to have a positive effect on export intensity.

As has been noted earlier, most of the empirical studies have included size as an explanatory variable in export equations. However, the findings of these studies have been mixed. In the present study though the sign of the correlation coefficient for MS with EXPI is negative, it is not statistically significant. Since quite a few studies (Kumar and Siddharthan, 1994; Patibandla, 1995; Sterlacchini, 1999) have also found non-linear relationship between size and exports, therefore in this study too square of the size, MS^2 has been included to explore the possibility of non-linear relationship existing between size and export intensity (this could also be the reason for correlation coefficient between MS and EXPI to turn out to be statistically insignificant in the present sample).

The mean age of the firm (AGE) in the present sample is around 26 years (see Table 3), which gives the impression that on an average the firms in this industry are fairly experienced. However, average export intensity for the sample is only around 16 percent in spite of the fact that there exist nearly hundred percent export oriented firms in the sample. This observation is reflected in the statistically significant negative correlation coefficient between AGE and EXPI. Therefore it is hypothesized that older firms may not be as export intensive as the younger firms in the present study.

As discussed earlier, not all firms might be successful in obtaining all the finances required for venturing into export market from external sources. Therefore the firms are likely to plough back their profits into activities that enhance their export competitiveness. The positive correlation coefficient between PROFIT and EXPI also supports this hypothesis. Therefore a positive sign is predicted for PROFIT.

The evidences discussed in Section 2 suggest that mostly the subcontracting firms are more export competitive than the subcontractor firms. In the Indian Basic Chemical industry too the completely vertically integrated firms might be the specialized subcontractors who are mainly catering to the needs of other domestic Chemical firms who in turn might be the ones producing the final product for export market. Therefore it is hypothesized that vertical integration (VI) would be negatively affecting the export intensity of the firm.

As discussed in Subsection 4.1 capital productivity (CAP) can be considered more relevant than capital intensity as a potential determinant of exports in Indian Basic Chemical industry. The sign for this variable is hypothesized to be positive for the present sample.

Most of the observations in the present sample are organic chemical producers and Section 3 too highlights that organic chemical producers perform better than inorganic chemical producers in export market. Again, Table 6 reveals that in the present sample too organic firms have average export intensity more than inorganic firms therefore the coefficient of dummy variable representing organic firms (D_{org}) is likely to have a positive sign.

6. Tobit Results and Interpretation

Table 8 shows the results for the Tobit model defined as equation 2 in Section 5. One can observe from Table 8 that all the four technology variables, RDI, MKI, LRI, and D_{fe} have statistically significant coefficients reinforcing the idea that technology related variables are important in determining exports.

Table 8: Tobit Results for Export Intensity as explained variable.

Sl. No.	Variables	Symbols	Coefficient
1	Constant	-	6.937 (1.40)
2	R&D Intensity	RDI	4.156 (1.88)*
3	Import of embodied technology (capital goods) Intensity	MKI	86.588 (1.70)*
4	Import of disembodied technology Intensity	LRI	-5.699 (-1.91)*
5	Age of the firm	AGE	-0.397 (-3.82)***
6	Profit Margin	PROFIT	0.104 (1.71)*
7	Vertical Integration	VI	-0.029 (-0.41)
8	Capital Productivity	CAP	-0.007 (-0.83)
9	Market Share	MS	9.320 (2.97)***
10	Square of Market Share	MS^2	-1.810 (-3.06)***
11	Dummy for Foreign Equity	D_{fe}	10.811 (3.73)***
12	Capital Imports' Intensity interacting with R&D intensity	MKI*RDI	-42.87 (-0.19)
13	Disembodied Technology Intensity interacting with R&D intensity	LRI*RDI	-0.660 (-0.09)
14	Foreign Equity Dummy interacting with R&D intensity	D_{fe}*RDI	-4.337 (-1.68)*
15	Dummy for Organic Chemical Firms	D_{org}	8.398 (2.85)***
18	Number of Observations		637
19	LR Chi^2		64.74***
20	Log likelihood		-2300.609

, **, * are 10%, 5% and 1% significance level respectively*
Values in bracket are t-statistics

As predicted intensity of capital goods import (MKI) and foreign equity participation (D_{fe}) affect export intensity positively. Again, import of disembodied technology (LRI) too is having the hypothesized negative sign. This is in contrast to the an earlier study by Kumar and Siddharthan (1994) where they had found technology variables to be insignificant in determining exports in the Indian Basic Industrial and Dyestuffs industry.

It seems that the better export performance of Indian Basic Chemical firms during the past few years has been mainly due to production of quality products using modern equipments acquired in the form of import of capital goods, due to improvement in the efficiency of production through acquisition of tacit managerial and technological skills from the foreign equity participants, and also due to use of brand names of the foreign firms. However any investments on acquiring technical information from abroad in the form of designs, drawings, and technical reports with production formulae have not been favorable for export performance. In-other words, in case of this industry, for better export performance presently improvement on know-how knowledge (that deals with knowing how the machinery and equipments work and how managerial and technical skills can be efficiently utilized for production) rather than know-why (that deals with knowing the underlying principles of a given production technique through understanding of designs, drawings, and technical reports) seems to be more important.

Incidentally, in-house R&D, that can be considered to be a factor in enhancing know-why knowledgebase, has a positive effect on export intensity. However one should also note that the level of technological capability in Indian Chemical and allied industries is supposed to be low as compared to the world especially due to the protected regime till 1991 (Ganguly, 1999 and Lall, 2000). Therefore it is likely that the in-house R&D investments are mainly aimed at enhancing the quality of the products to bring it up to world standards and/or to introduce small process innovations that would enable the firm to produce the standard products at cheaper rates.

Again, it should be noted that the effect of R&D in the firms with foreign equity participation (represented by the interactive variable [$RDI*D_{fe}$]) is negative. One may find this a little strange since coefficients of both R&D and foreign equity participation variables have a positive sign for the sample as a whole. However this finding can mean that in the specific technological strategy case of Indian firms with foreign equity participation also doing in-house R&D, the firms are mainly catering to the needs of domestic market. Therefore in such cases the R&D undertaken is more likely to be aimed at building up the technical and production capabilities in the employees of Indian affiliates through intra-firm transfer of technical workforce from abroad to Indian R&D centers. The technical workforce might also be undertaking some kind of adaptive R&D to make the production technology suitable for Indian situation. Due to lack of data the effect of intra-firm movement of technical workforce and its effect on export performance could not be verified in the present study.

Unlike the findings of Kumar and Siddharthan (1994) for the Indian Basic Industrial chemicals in the present study the size of the firm (in terms of market share) has turned out to be an important factor in determining exports. Further, the relationship has been found to be a non-linear one. Thus, the medium sized firms seem to be better export performers than

either the smaller or the larger firms in this industry. This could imply that the smaller firms may not be having sufficient resources and the larger firms may be already enjoying monopoly power in the domestic market, so both are not venturing into foreign markets.

Age of the firm (AGE) too has taken a sign that was hypothesized. Thus the newer firms seem to be finding export market to be more lucrative than experienced firms. This could also mean that the older firms are still using the traditional methods of production and thus are incapable of competing in the export market.

Coefficient of profit margin (PROFIT) has a positive sign as conjectured. This finding is in line with the argument that profitable firms are more likely to be able to take the risk to sell their products in foreign markets. It should be noted that Kumar and Siddharthan (1994) in an earlier study had found profitability to be negatively influencing export performance in the Basic Industrial Chemicals and Dyestuff industry of India.

The dummy variable for organic chemical producers (D_{org}) also takes a statistically significant positive sign therefore one can say that the product that the firm produces also determines the export performance of the firm in foreign markets. Though coefficient for vertical integration (VI) had the predicted sign but it was not statistically significant. Similarly the coefficient for capital productivity too didn't have a statistically significant sign. Therefore we can say that presently the degree of internalization of production process as well as the efficiency of utilization of the assets in production may not matter for international competitiveness for the firms belonging to Indian Basic Chemical industry.

7. Summary and Conclusion

The present study tried to investigate whether differences in the technological strategies adopted by the firm has any effect on the export competitiveness of the firms in Indian Basic Chemical industry. The study has also tried to understand which of the technological strategies is presently more effective for the better export performance in the industry. Both cross-tabulations and econometric analysis using Tobit model was utilized for the study. The results of the investigation have also brought to light some aspects of the industry that might require special attention, if the export competitiveness of the firms in the industry is to be further enhanced. In the present study on Indian Basic Chemical industry the following points are noteworthy:

1. In line with many other empirical studies this study also asserts that investment on technological strategies is an important determinant of export performance of a firm since coefficients of the four technology variables capturing in-house R&D, import of embodied technology, import of disembodied technology, and foreign equity participation turning out to be statistically significant. Disparities found in the effects of the different technological investments variables, including the interactive technological variables, reinforces the idea that the type of technological strategy adopted by a firm can be important in determining the export performance of the firm.

2. Presently the export competitiveness of the Indian Basic Chemical Industry seems to be in introducing quality products through use of advanced imported equipments, improving

the efficiency of the production thorough managerial and technical skill investments, and in using the marketing skills and brand names of the foreign equity holder firms. In other words, the technological activities that are likely to increase the know-how knowledgebase of the firms (that includes knowing how the machinery and equipments work, how managerial and technical skills can be efficiently utilized for production, and how effective marketing of product can be undertaken) seem to be more important for export competitiveness of the firms in this industry.

3. Import of disembodied technology in the form of design, drawings or new production formulae thorough licenses, royalties, and technical fees payments has a negative effect on export competitiveness. This means that the firms are not using the acquired know-why knowledge for competing in the export market. This could also mean that the acquired know-why technology, though new for Indian market, might be obsolete with respect to international market. The insignificant coefficient of interactive term of R&D with disembodied technology imports further supports the idea that presently the firms that are investing on imports of designs and drawings along with in-house R&D efforts seem to be failing to appropriately utilizing the technological investments for enhancing their export competitiveness. Therefore, to bring in export competitiveness in Indian Basic Chemical firms, it is important to encourage the use of innovative efforts like in-house R&D in the direction of new product innovations to complement the imported designs and drawings from abroad.

4. R&D intensity and foreign equity participation in general had a positive effect on export intensity, but R&D in firms with foreign equity participation had a negative effect on exports. Therefore one can say that some amount of product quality enhancing R&D in domestic firms and tacit knowledge transfer in firms with foreign equity participation is helping export performance of the firms in Basic Chemical Sector. At the same time some of the firms with foreign equity participation might be trying to capture the Indian markets by investing in adaptive R&D.

5. Presently, Indian organic chemical producers are more export intensive than inorganic chemical producers. Also, organic chemical sector has the largest share in the Indian Basic Chemical sector exports. Incidentally, most of the foreign technological collaborators in Basic Chemicals also come from the regions that are the top importers of the Indian chemicals. Therefore it is likely that the firms in this industry that have foreign equity participation or had some foreign collaboration in the past are mainly catering to the needs of the foreign parents or collaborators. At the same time, there is a need to encourage more research with or without foreign collaborations in inorganic chemicals sector so that inorganic chemical firms can also become at least as export competitive as organic chemical firms.

6. Most of the better exporting firms seem to be importing modern equipments from abroad which in turn points to the lack of modern equipment providers in India. Therefore there is a need to encourage technological investments in equipment manufacturing firms

who cater to the needs of Basic Chemical industry. It is more likely that the modern machines and equipments produced by the domestic manufacturers would be in accordance with the conditions (such as climate and availability of raw materials) found in India. Therefore the domestic firms that use the domestically made machines and equipments may be able to produce international quality products more economically.

7. Profit margin turned out to be important in determining export performance. This reinforces the idea that export is investment intensive activity and therefore may even require reinvestments of profits for better export performance in this industry. The younger firms who are likely to have started their production with the latest technologies seem to be performing better than the older firms who might be still using the obsolete technologies. Again, since medium sized firms are more export intensive than either their smaller or larger counterparts, it seems that the firms in this industry have to reach a minimum threshold size after which they perform better in the foreign market.

Two major limitations of the present study have been use of skill content of the workforce as another form of technological strategy and the use of balanced panel that could not account for effects of entry and exit of firms. Nevertheless differential export performance of the firms adopting various technological strategies in a specific industry has not been well researched in the context of developing countries. This paper is an attempt to fill this gap in the industrial organization literature.

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